Pak. J. Bot., 51(5): 1883-1889, 2019. DOI: http://dx.doi.org/10.30848/PJB2019-5(1)

EFFECT OF VERMICOMPOST AND OTHER FERTILIZERS ON SOIL MICROBIAL POPULATION AND GROWTH PARAMETERS OF F_1 MONGAL TOMATO (*SOLANUM LYCOPERSICUM* L.)

YUNITA P. ARJUNE[1], A. A. ANSARI[1], SIRPAUL JAIKISHUN[1,2] AND OUDHO HOMENAUTH[3]

[1]Department of Biology, Faculty of Natural Sciences, University of Guyana, Guyana
[2]Haxia Institute of Science and Technology, Life Sciences College, Fujian Agriculture and Forestry University, Fuzhou, China
[3]National Agricultural Research and Extension Institute, Agriculture Road, Mon Repos, East Coast Demerara, Guyana
**Corresponding author's email: abdullahadilansari@gmail.com*

Abstract

This study aims to investigate the effect of vermicompost and other fertilizers on the growth of F_1 Mongal tomato (*Solanum lycopersicum* L.). The treatments used were vermicompost (T1), promix (T2), 189 components (T3) and a combination of 189 and vermicompost (T4). The study showed that in T1 there was maximum increase in *Azotobacter* count (7.04%) whereas T3 was better in terms of *Nitrosomonas* (111.72%) in soil medium used for cultivation. Increase in plant height was maximum in T1 (1217.28%) followed by T2 whereas greater increase in number of leaves was recorded for T1 (2387.9%) followed by T3 which was statistically significant based ANOVA. Vermicompost (T1) was highly effective in influencing plant growth and fruit parameters than the other treatments based on rank analysis of all the parameters.

Key words: Earthworms, Sustainable agriculture, Microbial count, Plant nutrients and Vermicompost

Introduction

Tomato *(Solanum lycopersicum* L.) is a widely grown and consumed in the world for centuries (Al-Amri, 2013). Tomato originated in Central and Southern America, and is rich in carotenoids and phenolic compounds with antioxidant and anti-inflammatory effects and play a critical role in the defence against oxidative stress and other chronic diseases (Al-Amri, 2013; Li *et al.*, 2014). The crop is susceptible to a number of attacks by insect pests from the time when the plant first emerges in the seed bed until harvest. It is widely used for human consumption either cooked or raw. Vermicomposting is the process of using earthworms for the degradation of organic materials to produce vermicompost. The earthworms are useful in breaking the organic substances faster; they stimulate microbial activities in the vermicompost, increase the mineralization rate having better water holding capacity (Ansari & Ismail, 2012).Vermicomposting also offers an environmentally friendly way of reducing the amount of waste being disposed of by industries and from homes. Household scraps and industrial organic waste can be utilized by earthworms, thereby reducing global warming and pollution (Ansari & Ismail, 2012; Jaikishun *et al.*, 2014).

With more growing pressures resulting from perspectives of human health, biological and environmental systems to drastically reduce the use of chemical fertilizers and pesticides, vermicompost and vermiwash can be used as biofertilizers in organic farming. Growing our crops with vermicompost improves plant health and with favourable influence on growth parameters of many plants (Tharmaraj *et al.*, 2011). The vermicompost has pesticidal properties and slowly releases fertilizer as compared to the chemical fertilizers which is depleted faster due to its release of nutrients too quickly (Sinha *et al.*, 2010). These earthworms have significant influences on soil by improving the soil fertility through decomposition of leave litters and other materials and releasing nutrients in the soil in a form that is easily accessible to plants. Aristotle had referred to earthworms as being the intestine of the earth and also the restoring agent in soil fertility (Ismail, 1995; Ismail, 2005). The presence of earthworms indicates the presence of bacteria, fungi, viruses, and other organisms which characterizes healthy soil (Ansari & Ismail, 2012; Mane & Raskar, 2012; Ramnarain *et al.*, 2019). The biochemical decomposition of organic matter is achieved by the actions of earthworms in contact with microorganisms. The microorganism from the earthworm's cast along with those found in the soil then work together to speed up the rate of decomposition of the organic matter. The end product is the vermicompost and it contains high amounts of nutrients and also boosts soil aeration (Domínguez & Gómez-Brandón, 2012).

In Guyana, the most effective and popular species of earthworm used in vermicomposting is the California red worm (*Eisenia fetida:* Lumbericidea). This epigeic species is characterized by its colour, which ranges from red, purple or brown. The habitat of *E. fetida* encapsulates an area that is high in organic matter such as forest area with significant amount of leaf litter, mass manure areas, damp grass land and other areas with much organic wastes (Edwards *et al.*, 2010; Dominguez, 2011; Fadaee, 2012).

Vermicompost used in organic farming produces higher yield of crops which are safer and chemical free when compared to plants grown with chemical fertilizers. It also enhances flowering and physical properties of the fruits (Ismail, 2005; Jaikishun *et al.*, 2014). The availability of nutrients from vermicompost is readily available to plants where as with chemical fertilizers it has to be broken down first before the plant can obtain the nutrients. Also, the humus in the vermicompost gives it a greater water holding capacity than chemical fertilizers which needs a lot of water for irrigation (Singh *et al.*, 2010; Sundararasu & Neelanarayanan, 2012; Jaikishun *et al.*, 2014). The properties of the vermicompost which promotes plant growth are the fact that they are rich in bio nutrients which are required for the growth of plants, these includes nitrates, phosphates, soluble potassium, magnesium and exchangeable phosphorus and calcium (Arancon & Edwards, 2005).

Vermicompost is also rich in beneficial microbes such as fungi, bacteria and also actinomycetes. Gut microflora of earthworms process the organic waste and convert to vermicompost that helps to promote plant growth. These microbes and earthworms secrete plant growth hormones such as gibberellins, auxins and cytokinins. The influence of these hormones in vermicompost shows improved seed germination; enhanced seedling growth, increased productivity and better fruit quality (Sinha *et al.*, 2010; Dominguez, 2011; Sinha *et al.*, 2011; Ansari & Ismail, 2012). During vermicomposting, humic acid is secreted by the earthworm that enhances nutrient uptake by the plants by increasing permeability of root cell membrane, stimulating root growth and proliferation of root hair. Singh *et al.*, (2010) studied the effect of vermicompost and NPK fertilizers on morpho-physiological traits of plants, yield and quality of tomato fruits. The combination of vermicompost with NPK fertilizers give an increased plant height, leaf area, leaf weight, fruit weight, fruit yield, fruit density, and post-harvest life. The main aim of his research was to assess the morphological growth responses of tomato grown with vermicompost (T1), promix (T2), 189 components (T3) and a combination of 189 and vermicompost (T4). Additionally, microbial composition of the substrates used was also analysed before and upon completion of the experiment.

Materials and Methods

Vermicomposting unit preparation: The vermicomposting units (2.1x2.1x1m^3 dimensions) were set up at the National Agricultural Research & Extension Institute (NAREI) located at Mon Repos. The basal layer consisted of pebbles then layered with course sand about 10 inches for proper drainage. Placed on top of the already established layers were 10 inches of loamy soil after which 500 locally collected earthworms (*Eisenia fetida*) were introduced (Fig. 1). Fresh cattle dung was collected and placed on the soil and then it was covered with 5 inches of dried grass clippings and leaves, water was then sprinkled to keep the unit moist. The layer of cattle dung and leaves was turned weekly. After 60 days, the vermicompost units were regularized and subsequently harvesting of vermicompost every 45 days. The vermicompost collected was then subjected to physico-chemical and microbial analyses (Ismail, 2005; Ansari & Ismail, 2012; Domínguez & Gómez-Brandón, 2012).

Experimental design and treatments: The experiments were carried out in randomised block design system with three biological replicates per treatment. The treatments (Table 1) were T1 - Vermicompost [VC], T2 - Promix, T3 - 189 (NAREI) [189] and T4 – Vermicompost +189 [VC+189] for the cultivation of F_1 Mongal tomato (*S. lycopersicum* L.).

Fig. 1. *Eisenia fetida* used in Vermicomposting.

Field planting: Seedlings were transplanted in pots containing sand with 500 g of substrate and placed in a completely randomized block design with three replications. At the flowering time, 250 g of the respective substrate was added to plants. Percentage survival, number of leaves, leaf surface area, flowering time and number and weight of fruits, shoot and root length, shoot and root weight (fresh and dry) and total biomass were recorded. Vitamin C content was also analyzed (Anon., 2012). Neem extract was prepared by boiling 600 g of leaves with 1 litre of water. This was diluted by adding 5 litres of water and then 50 ml of solution and then sprayed to the plants before flowering and fruiting.

Microbial analysis: Analysis was done for initial and final soil samples. Culture was done on nutrient agar and samples inoculated at 35°C for 24 hours. Gram staining was done using a thin smear of bacterial colony on separate slides and left to air dry. The smears were then fixed by swiftly heating through a Bunsen flame. The slide was flooded with crystal violet and then washed with distilled water for few seconds. The slides were then flooded with Gram iodine and then decolorized by tilting slide and drop by drop rinsing with 95% ethanol until ethanol runs clear. It was then washed with distilled water for a few seconds. The slide was then flooded with safranin and thereafter, washed with distilled water. The slide was then blot dried and then viewed under microscope to identify the shape of the bacteria and the gram reaction of bacteria (Aneja, 2007; Karabulut & Ozturk, 2015).

Table 1. Treatments.

Treatments	Details of each treatment
T1	**Promix**-Canadian sphagnum peat moss, perlite, vermiculite, macro nutrients and micronutrients, limestone, wetting agents and mycorrhizae.
T2	**Vermicompost**-Grass clippings and cattle dung vermicomposted using *E. fetida*
T3	189 NAREI-450 g of sand, 550 g sawdust, 90 g chicken litter, 20 g triple super phosphate (tsp), 8 g urea, 0.013g of calcium carbonate ($CaCO_3$) and 0.4 g molybdenum potash (MoP)
T4	**189 + Vermicompost**

Isolation and enumeration of *Azotobacter* colonies: The weighed amounts of mannitol, $MgSO_4.7H_2O$ (20 g), NaCl (0.2 g), K_2SO_4 (0.1 g), $CaCO_3$ (5.0 g) were dissolved in 200 cm^3 of distilled water in a 250 cm^3 conical flask. In another flask, K_2HPO_4 (0.2 g) was dissolved into 100 cm^3 of water. This was then made up to 1000 cm^3 with distilled water and added to a container with 20 g of agar. The mixture was then dispensed into 5-200 cm^3 portions into conical flasks which was then plugged with cotton wool and thereafter wrapped with aluminium foil as the cap. The Ashby's medium was autoclaved at 121°C for 15 minutes. Upon cooling the medium was then poured into petri dishes in strict aseptic conditions. About 10 g of sieved compost (2 mm) was then added to a beaker containing 90 cm^3 of sterile water and shaken for 15-20 minutes on a magnetic shaker. An amount of 1 cm^3 of aliquots of the different dilution was added over cooled and solidified agar medium in Petri plates. The plates were then rotated for uniform distribution of spores and then incubated at 28°C for 3 days (Aneja, 2007; Malik *et. al.*, 2014).

Isolation and enumeration of *Nitrosomonas* colonies: The weighed amounts of solids {2.0 g of ammonium sulphate $(NH_4)_2SO_4$, 2.0 g of dipotassium hydrogen phosphate (K_2HPO_4), 2.0 g Sodium chloride (NaCl), 0.5 g of magnesium sulphate ($MgSO_4$. $7H_2O$), 0.01 g of ferrous sulphate ($FeSO_4.7H_2O$)} and placed in a 250 cm^3 conical flask and dissolved in 200 cm^3 of distilled water. In another flask, calcium carbonate was dissolved into 100 cm^3 of water. All the constituents were made up to 1000 cm^3 by the addition of more distilled water. The mixture was then heated and the agar was added and thoroughly shaken then dispensed into 5-200 cm^3 portions into conical flasks which would then be plugged with cotton wool and thereafter wrapped with aluminium foil as a cap. The medium was sterilized at 121°C for 15 minutes in an autoclave. Upon completion, the flasks were cooled and modified Winogradsky medium then poured into petri dishes under strict aseptic conditions. About 10 g of sieved compost (2 mm) was then added to 90 cm^3 sterile water and shaken for 15-20 minutes on a magnetic shaker. Serial dilutions were prepared for 10-2 and 10-3.1 cm^3 of aliquots of the different dilutions were then added over cooled and solidified agar medium in Petri plates. The plates were then rotated for uniform distribution of spores and then incubated at 28°C for 3 days (Aneja, 2007; Gomathinayagam *et. al.*, 2012; Karabulut & Ozturk, 2015).

Results

The farming system use fertilizers for plant growth as the soil cannot provide sufficient nutrients for the optimum growth of crops. In recent times efforts are made to conserve and ameliorate the soil ecosystem in terms of maintaining soil fertility by incorporating organic inputs like vermicompost. These series of experiments were conducted to compare the role of chemical and organic fertilizers on plant growth parameters of Mongal tomato plants (*Solanum lycopersicum* L.). Plants were treated with four different treatments (T1: Vermicompost, T2: Promix, T3: 189 NAREI and T4: 189 + Vermicompost).

Microbial analysis of pre and post experimental soil samples: Figure 2 shows the changes in microbial count (total bacteria and total fungi) in soil samples taken before and after the conclusion of the experiments with application of different treatments. There was increase (143.26 %) in total bacterial count in T2 compared to other treatments which was highly significant (p=0.036 based on paired t test). In the other treatments decrease in numbers was recorded. The increase in total fungal count was observed in T2 compared to other treatments but was not significant statistically (p=0.13 based on paired t-test).

There was increase in *Azotobacter* count in T1 (7.04 %) which was statistically not significant (p=0.36 based on paired t test) compared to other treatments where significant decrease was recorded (p=0.005, 0.01 and 0.003 based on paired t test). The change in *Nitrosomonas* count was highly significant for all the treatments p=0.027, 0.003, 0.003 and 0.047 based on paired t test). The count was maximum in T3 (111.72 %) followed by T1 (61.04 %) (Table 2).

Plant growth parameters: The change in plant height (Table 3) on a weekly basis showed an increase in each treatment over the 13 week period. The initial plant height showed the highest in T4 (9.37 cm) treatment followed by T3 (9.33 cm), T2 (8.2 cm), T1 (7.87 cm), respectively. The final plant height showed the highest recorded height in treatment T1 (103.67 cm) followed by T4 (100.23 cm), T3 (87.33 cm), and T2 (84.93 cm) respectively. In terms of percentage increase over the 13 week period, the highest increase in plant height was seen in T1 followed by T4, T2 and T3 respectively. The increase in plant height is highly significant based on ANOVA over the 13 weeks period between the four treatments (p= 4.81E-15, 2.81E-05).

The number of leaves obtained over the 13 week period showed the initial highest from treatment T3 (26.33) followed by T4 (25), T2 (24.33) and T1 (21.33) respectively. Final number of leaves displayed the highest from treatment T1 (530.67) followed by treatments T3 (473.33), T4 (355.67), T2 (136.33). Percentage change in number of leaves was highest in treatment T1 (2387.90 %). The second highest percentage change was seen in treatment T3 (1697.68 %) and T4 (1322.68 %) being the third highest. The least number of changes was seen in treatment T2 (460.34 %) (Table 4). The increase in number of leaves is highly significant based on ANOVA over the 13 weeks period between the four treatments (p= 3.97E-06, 1.56E-07).

The highest plant parameter in terms of number of leaves was seen in T1 (530.67) followed by T3 (473.33), T4 (355.67) and T2 (136.33) respectively. The tallest plant was seen in T1 (103.67) which followed by T4 (100.23), T3 (87.33) and T2 (84.92). Number of branches showed the highest in T4 (14.33) followed by T3 (13.33) and T1 (13.33). The diameter of the plant stem showed the highest diameter in treatment T3 (1.47) followed by T4 (1.40). The least diameter was seen in treatments T1 and T2 both having the same diameter (1.13 cm). The highest mean fruit weight was seen in treatment T2 (35.28) followed by T3 (33.53), T1 (32.79) and T4 (32.46) (Fig. 3). Treatment T1 was found to be most productive in terms of all the plant growth and fruit parameters based on rank analysis (Table 5).

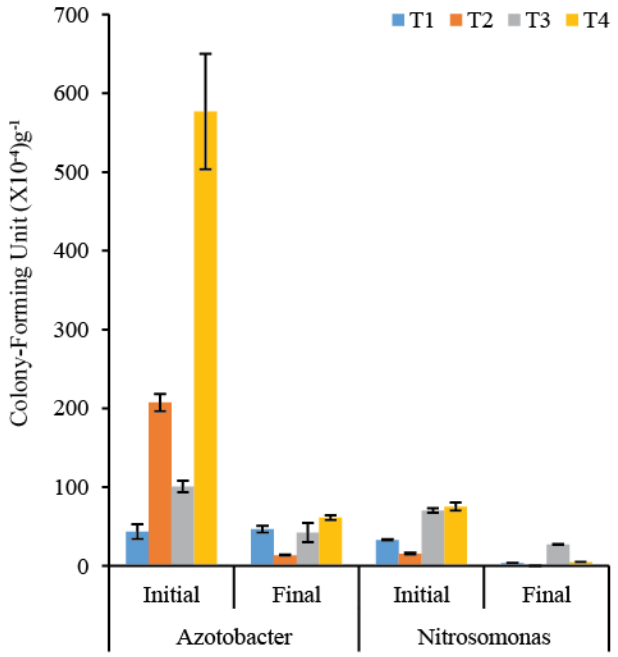

Fig. 2. Changes in microbial count in soil samples taken before and after the experiments. Data represents Mean ± Standard deviation of three biological replicates.

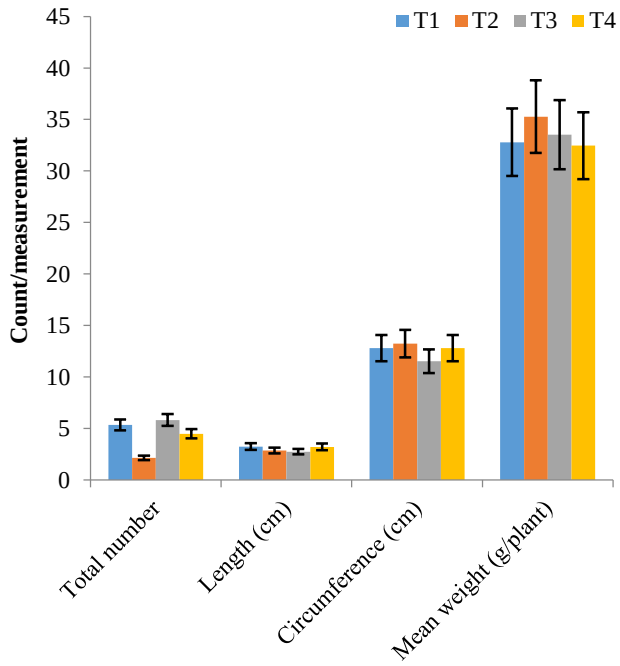

Fig. 3. Morphology of fruits harvested from the different treatments. Data represents mean ± standard deviation of three biological replicates.

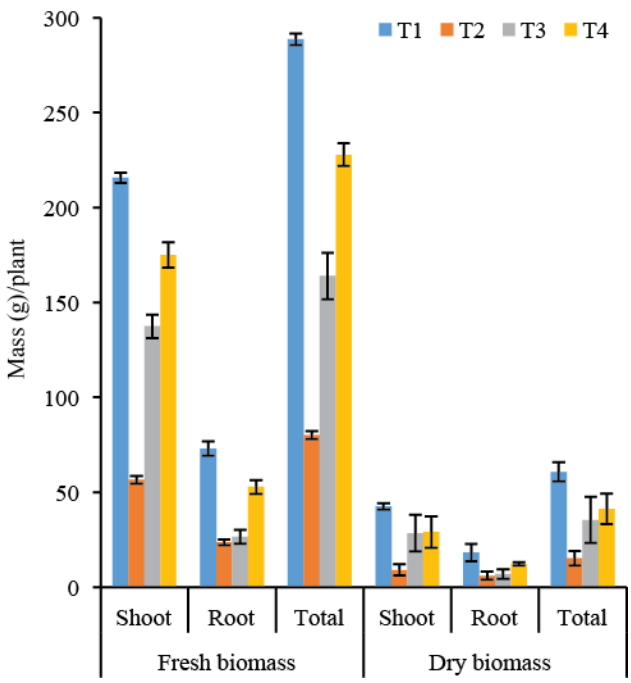

Fig. 4. Total, shoot and root biomass of plants (fresh and dry). Data represents Mean ± Standard deviation of three biological replicates.

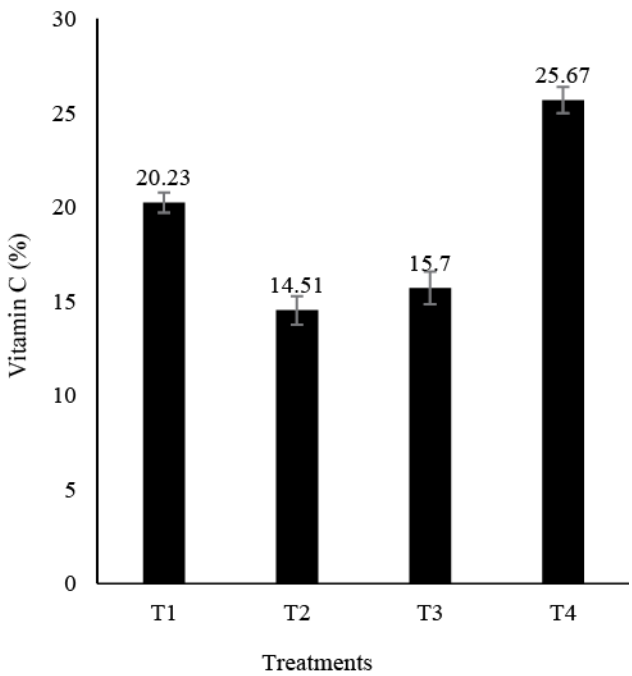

Fig. 5. Vitamin C content of fruits harvested from the different treatments. Data represents mean ± standard deviation of three biological replicate.

Table 2. Azotobacter and Nitrosomonas count from serial dilution (Mean ± Standard deviation).

Treatment	Azotobacter CFU(x 10^2)/g			Nitrosomonas CFU(x 10^2)/g		
	Initial	Final	% Change	Initial	Final	% Change
T1	43.67 ± 9.29	46.67 ± 4.16	7.04	45.33 ± 7.23	73 ± 5.29	61.04
T2	207.33 ± 11.02	13.67 ± 0.58	-93.41	102 ± 12.49	17 ± 1	-83.33
T3	100.67 ± 7.23	42.33 ± 12.22	-57.95	119.34 ± 4.04	252.67 ± 16.77	111.72
T4	576.67 ± 73.26	61.33 ± 3.06	-89.36	107 ± 1.73	104.34 ± 2.08	-2.49

Table 3. Change in plant height on a weekly basis (Mean ± Standard deviation).

Weeks	Plant height (cm)			
	T1	T2	T3	T4
1	7.87 ± 1.10	8.20 ± 0.20	9.33 ± 0.86	9.37 ± 1.03
2	14.53 ± 40.74	16.83 ± 3.33	14.83 ± 1.04	15.27 ± 2.86
3	33.9 ± 18.83	37.03 ± 2.65	51.93 ± 11.68	36.93 ± 10.62
4	52.57 ± 5.30	43.27 ± 1.42	56.00 ± 5.47	47.57 ± 10.04
5	69.17 ± 3.75	53.60 ± 5.28	64.47 ± 7.37	59.80 ± 9.77
6	81.67 ± 4.01	59.10 ± 8.00	70.33 ± 0.29	71.23 ± 6.81
7	88.73 ± 3.50	60.33 ± 6.51	72.90 ± 5.99	78.07 ± 4.24
8	95.00 ± 4.36	62.50 ± 8.53	77.67 ± 9.61	85.50 ± 3.97
9	95.33 ± 8.61	62.90 ± 10.65	79.00 ± 6.08	90.33 ± 8.31
10	97.83 ± 12.00	66.33 ± 16.17	83.30 ± 8.58	89.13 ± 9.07
11	98.00 ± 11.91	77.67 ± 14.05	83.67 ± 8.39	90.87 ± 7.31
12	102.5 ± 8.79	76.67 ± 15.14	85.67 ± 10.21	97.33 ± 2.47
13	103.67 ± 11.02	84.93 ± 10.71	87.33 ± 13.20	100.23 ± 4.56
% Change in height	1217.28	935.73	836.01	969.69

Table 4. Number of leaves recorded on a weekly basis for 13 weeks (Mean ± Standard deviation).

Weeks	T1	T2	T3	T4
1	21.33 ± 6.03	24.33 ± 1.15	26.33 ± 12.50	25.00 ± 2.65
2	41.00 ± 6.56	46.33 ± 9.45	62.33 ± 29.28	47.33 ± 10.12
3	168.67 ± 46.32	136.67 ± 21.55	242.00 ± 80.73	130.00 ± 47.66
4	229.67 ± 72.17	157.67 ± 22.74	350.00 ± 136.01	167.00 ± 70.45
5	273.67 ± 76.16	181.67 ± 18.93	295.33 ± 177.27	234.67 ± 96.77
6	517.67 ± 69.14	189.00 ± 24.33	388.33 ± 81.35	313.33 ± 114.63
7	550.67 ± 84.11	190.33 ± 10.02	420.00 ± 78.35	389.67 ± 57.59
8	530.00 ± 90.54	161.00 ± 54.56	409.67 ± 38.42	368.67 ± 85.51
9	521.00 ± 96.15	161.00 ± 54.00	417.67 ± 75.22	364.33 ± 85.35
10	441.33 ± 33.01	167.00 ± 31.61	476.00 ± 212.86	334.67 ± 71.90
11	538.00 ± 49.39	175.00 ± 20.00	468.33 ± 149.37	345.33 ± 11.93
12	517.00 ± 5.00	178.33 ± 46.44	445.00 ± 237.69	42.001 ± 49.87
13	530.67 ± 24.54	136.33 ± 41.20	473.33 ± 159.48	355.67 ± 66.89
% Change in no. of leaves	2387.90	460.34	1697.68	1322.68

Table 5. Plant and fruit morphological features at harvest. (Mean ± Standard deviation).

S. No.	Plant growth parameter	T1	T2	T3	T4
1.	Plant height (cm)	103.67±11.02	84.93±10.71	87.33±13.20	100.23±4.56
2.	No. of branches	13.33±1.53	13.00±1.00	13.33±3.21	14.33±1.15
3.	No. of leaves	530.67±24.54	136.33±41.20	473.33±159.48	355.67±66.89
4.	Stem diameter (cm)	1.13±0.00	1.13±0.23	1.47±0.06	1.40±0.17
5.	Total no. of fruits	5.35±1.92	2.17±0.76	5.83±1.89	4.50±1.32
6.	Average length of fruit (cm)	3.25±0.26	2.87±0.23	2.76±0.09	3.22±0.81
7.	Average circumference of fruit (cm)	12.80±0.63	13.24±1.81	11.53±0.47	12.81±0.63
8.	Average weight of fruit(g)	32.79±4.09	35.28±16.28	33.53±9.32	32.46±4.78
9.	Total weight of the fruits per plant (g)	313.27±46.06	92.03±57.65	33.53±21.34	314.51±64.55

The highest fresh shoot weight was seen in T1 (215.67 g) followed by T4 (175.03 g), T3 (137.43 g) and T2 (56.57 g) respectively. The highest dry weight was also observed in Treatment T1 (42.47 g) and the lowest in treatment T2 (9.13 g). Fresh and dry root biomass showed similar result with significant difference in their weight where T1 was highest for each parameter. The dry biomass of the roots however was lowest in T3 (Fig. 4).

The vitamin C content (Fig. 5) found in the fruits obtained from the plants of different treatments showed the highest in treatment T4 (25.67 %) followed by T1 (20.23 %) and T3 (15.7 %).

Discussion

Different treatments that were used for cultivation of treatments were assessed for total microbial count (bacteria and fungi) and there was significant increase in CFU's in treatment T2 which may be attributed to the composition (organic) of T2 which consists of Canadian sphagnum peat moss, perlite, vermiculite, macro nutrients and micronutrients, limestone, wetting agents and mycorrhizae. This facilitates the microbial sustainability and growth in the soil. On the other hand the total microbes also include others that are not beneficial but

may have negative impact on soil processes. The increase may not reflect the true picture of the microbiota in the soil. This may account for the increase in the other treatments (Ganeshnauth *et al.*, 2018).

Soil micro-organisms play a vital role in maintaining soil fertility and structure. *Azotobacter* and *Nitrosomonas* are known free-living nitrifying bacteria that colonize plant roots and potentially produced phyto-hormone, engaged in antifungal activities and promoted phosphate solubilization (Dominguez, 2011; Domínguez & Gómez-Brandón, 2012; Ibiene *et. al.*, 2012). The increase in *Azotobacter* and *Nitrosomonas* count in T1 can be attributed to stimulants present in vermicompost on application enhance the growth and activity of *Azotobacter* in soil. However, decrease in other treatments may result from the inhibitory effect on *Azotobacter* by components of other treatments (Devi *et al.*, 2012; Rajasekar *et al.*, 2012).

The highest increase in plant height obtained from treatment T1 correlates with the research conducted by Joshi & Vig (2010) and Zucco *et al.*, (2015). Vermicompost has high microbial activity due to the presence of bacteria, fungi etc. which produces plant growth hormones such as auxins, gibberellins, cytokinins, ethylene and abscisic acid (Joshi & Vig, 2010; Dominguez, 2011; Rajasekar *et al.*, 2012). Plants grow the least using saw dust because it is carbonaceous which may result in immobilization of nutrients that the plants need for growth. The organic component of the 189 does not attribute any effect to the saw dust because of its small proportion (Gbemisola *et al.*, 2010). Some organic matter may take a long time to decompose to form humus but earthworms excrete this substance as it ingests organic matter. Humus is a substance which has many properties such as enabling plants to obtain nutrients from soil, helping plants to overcome stress etc. due to the presence of humic and fulvic acids, hence promoting better plant health and growth (Lazcano *et al.*, 2009; Sinha *et al.*, 2010).

The better performance of T1 for plant growth and fruit parameters based on rank analysis correlates with the work of Bhunia & Chakraborty (2011), who experimented on the effect of vermicompost and other fertilizers, each with the same concentration of nutrients, on the growth of tomato plant (*L. esculentum* Mill). Vermicompost + chemical fertilizers showed 73% better yield in fruiting than the other fertilizers used. Moreover, this treatment showed high production in fresh and dry weight of leaves, dry weight of fruits, and number of branches. The highest number of branching for a plant was found for the organic fertilizer but the overall stem lengths were higher in the chemically treated plant (Özer, 2017; Ansari *et al.*, 2019). Similarly, Ansari and Jaikishun (2011) quantitatively compared sugar cane bagasse and rice straw vermicompost and their utilization for the growth of *Phaseolus vulgaris* L. The vermicompost showed the highest or best growth of *P. vulgaris* rather than chemical fertilizers. Vermicompost retained its nutrients longer than chemical fertilizers. In fruit quality, it showed better physical dimensions by having the highest circumference, highest number of seeds and highest fruit mass and higher biochemical constituents. Bhunia & Chakraborty (2011) showed similar results in which vermicompost resulted in better plant growth in relation to shoot and root biomass. Microorganisms found in vermicompost fertilizers may be beneficial to plants by exerting phytohormones which would result in increased root biomass, plant growth and development. Rhizobacteria such as *Azotobacter* and *Nitrosomonas* found in the root of the plants are responsible for making nitrogen available to the plant increasing its biomass (Ibiene *et al.*, 2012).

Conclusion

In conclusion, this work emphasizes the importance of vermicompost in growing *S. lycopersicum* as an alternative to chemical fertilizers. Vermicompost can be used effectively as an organic fertilizer for growing tomato (*S. lycopersicum*) as contains the requisite nutrients for better growth parameter and productivity. It showed better plant growth with reference to leaf number, plant height and fruit quality. This could be cost effective and environmental sustainable method of cultivation of crops such as tomatoes.

References

Al-Amri, S.M. 2013. Improved growth, productivity and quality of tomato (*Solanum lycopersicum* L.) plants through application of shikimic acid. *Saudi J. Biol. Sci*., 20: 339-345.

Aneja, K. 2007. *Experiments in microbiology, plant pathology and biotechnology*. New Age International.

Ansari, A. and S. Ismail. 2012. Role of earthworms in Vermitechnology. *J. Agri. Technol.*, 8: 403-415.

Ansari, A. and S. Jaikishun. 2011. Vermicomposting of sugarcane bagasse and rice straw and its impact on the cultivation of *Phaseolus vulgaris* L. in Guyana, South America. *J. Agri. Technol*., 7: 225-234.

Ansari, A.A., H. Raghubeer and S. Jaikishun. 2019. The effect of vermiwash and vermicompost produced from leaves of *Azadirachta indica* and *Citrus aurantifolia* on the growth parameters of celery through hydroponic system. *Trop. Drylands*, 3: 11-16.

Anonymous. 2012. "Official Methods. (A.O.A.C.)." American Organisation of Agricultural Chemists, Washington, D.C. U.S.A.

Arancon, N. and C.A. Edwards. 2005. Effects of vermicomposts on plant growth. International Symposium Workshop on Vermitechnology. Philippines.

Bhunia, G. and S.K. Chakraborty. 2011. The effect of vermicompost and other fertilizers on cultivation of tomato plants. *J. Hortic. For.*, 3: 42-45.

Devi, S., C.R. Sharma and K. Singh. 2012. Microbiological biodiversity in poultry and paddy straw wastes in composting systems. *Braz. J. Microbiol.*, 43: 288-296.

Dominguez, J. 2011. The Microbiology of Vermicomposting. In: *Vermiculture Technology: Earthworms, Organic Waste and Environmental Management* (eds. Clive A. Edwards, Norman, QA & Sherman, RL). CRC Press Boca Raton, Florida, pp. 397-408.

Domínguez, J. and M. Gómez-Brandón. 2012. Vermicomposting: Composting with Earthworms to Recycle Organic Wastes. In: *Management of Organic Waste*. (Eds.): Kumar, S & Bharti, A. Intech Open Science Rijeka, Croacia, pp. 29-48.

Edwards, C.A., N.Q. Arancon and R.L. Sherman. 2010. *Vermiculture technology: earthworms, organic wastes, and environmental management*. CRC press.

Fadaee, R. 2012. A review on earthworm Esieniafetida and its applications. *Ann. Biol. Res.*, 2500-2506.

Ganeshnauth, V., S. Jaikishun, A.A. Ansari and O. Homenauth. 2018. The effect of vermicompost and other fertilizers on the growth and productivity of pepper plants in Guyana. In: *Automation in Agriculture-Securing Food Supplies for Future Generations*. Intech Open.

Gbemisola, O.O., O. Akin, O.T. Aladesanmi, S. Maruf, A.J. Famurewa and W.O. Siyanbola. 2010. Risk mitigation strategies and policy implications for carbon dioxide (CO 2) emission in organically-amended soils in Nigeria. *Afr. J. Environ. Sci. Technol.*, 4: 801-806.

Gomathinayagam, S., S.A. Persaud and M. Rekha. 2012. Comparative study of biological agents, Trichoderma harzianum and Trichoderma viride for controlling brown spot disease in rice. *Journal of Biopesticides*, 5: 28.

Ibiene, A., J. Agogbua, I. Okanko and G. Nwachi. 2012. Plant growth promoting rhizobacteria (PGPR) as biofertilizer: Effect on growth of Lycopersicum esculentum. *J. Amer. Sci.*, 8: 2-19.

Ismail, S.A. 1995. Earthworms in soil fertility management. *Organic agriculture*, 77: 100-106.

Ismail, S.A. 2005. *The Earthworm Book. Other India Press, Mapusa, Goa.* 101.

Jaikishun, S., N. Hunte, A. Ansari and S. Gomathinayagam. 2014. Effect of vermiwash from different sources (Bagasse, neem, paddy straw, in different combinations) in controlling fungal diseases and growth of tomato (*Lycopersicon esculentum*) fruits in Guyana. *J. Biol. Sci.*, 14: 501.

Joshi, R. and A.P. Vig. 2010. Effect of vermicompost on growth, yield and quality of tomato (*Lycopersicum esculentum* L). *Afr. J. Basic Appl. Sci.*, 2: 117-123.

Karabulut, G. and S. Ozturk. 2015. Antifungal activity of *Evernia prunastri*, *Parmelia sulcata*, *Pseudevernia furfuracea* var. *furfuracea*. *Pak. J. Bot.*, 47: 1575-1579.

Lazcano, C., J. Arnold, J. Zaller, J.D. Martín and A.T. Salgado. 2009. Compost and vermicompost as nursery pot components: effects on tomato plant growth and morphology. *Span. J. Agric. Res.*, 944-951.

Li, H., Z. Deng, R. Liu, S. Loewen and R. Tsao. 2014. Bioaccessibility, *In vitro* antioxidant activities and *In vivo* anti-inflammatory activities of a purple tomato (*Solanum lycopersicum* L.). *Food Chem.*, 159: 353-360.

Malik, F., S. Hussain and S. Mahmood. 2014. Appraisal of medicinal plants used in alternative systems of Medicines for microbial contamination, physiochemical Parameters and heavy metals. *Pak. J. Bot*., 46: 645-658.

Mane, T. and S. Raskar. 2012. Management of Agriculture Waste from Market yard Through Vermicomposting. *Res. J. Recent Sci.*, 289-296.

Özer, H. 2017. Effects of shading and organic fertiizers on tomato yield and quality. *Pak. J. Bot.*, 49: 1849-1855.

Rajasekar, K., T. Daniel and N. Karmegam. 2012. Microbial Enrichment of Vermicompost. *ISRN Soil Science*, 2012, 13.

Ramnarain, Y.I., A.A. Ansari and L. Ori. 2019. Vermicomposting of different organic materials using the epigeic earthworm Eisenia foetida. *Int. J. Recycl. Org. Waste Agric.*, 8: 23-36.

Singh, B., K. Pathak, T. Boopathi and B. Deka. 2010. Vermicompost and NPK fertilizer effects on morpho-physiological traits of plants, yield and quality of tomato fruits:(*Solanum lycopersicum* L.). *Vegetable Crops Research Bulletin*, 73: 77-86.

Sinha, R., G. Hahn, P. Singh, R. Suhane and A. Anthonyreddy. 2011. Organic farming by vermiculture: Producing Safe, Nutritive and Protective Foods by Earthworms (Charles Darwin's Friends of Farmers). . *Amer. J. Exp. Agri.*, 1: 363-399.

Sinha, R.K., S. Agarwal, K. Chauhan and D. Valani. 2010. The wonders of earthworms and its vermicompost in farm production: Charles Darwin's 'friends of farmers', with potential to replace destructive chemical fertilizers from agriculture. *Agri. Sc.*, 1: 76-94.

Sundararasu, K. and P. Neelanarayanan. 2012. Effect of vermicompost and inorganic fertilizer on the growth and yield of tomato, *Lycorpersium esculentum* L. *Int. J. Curr. Res*, 4: 9-051.

Tharmaraj, K., P. Ganesh, K. Kolanjinathan, R. Suresh Kumar and A. Anandan. 2011. Influence of vermicompost and vermiwash on physico chemical properties of rice cultivated soil. *Curr. Bot.*

Zucco, M.A., S.A. Walters, S.-K. Chong, B.P. Klubek and J.G. Masabni. 2015. Effect of soil type and vermicompost applications on tomato growth. *Int. J. Recycl. Org. Waste Agric.*, 4: 135-141.

(Received for publication 25 February 2018)